Population estimates and trends of Campbell and grey-headed albatrosses at Campbell Island

Campbell and grey-headed albatross population estimates

Prepared for the Department of Conservation

May 2014

26 May 2014 3.46 p.m.

Authors/Contributors:
Paul Sagar

For any information regarding this report please contact:

Paul Sagar
Group Manager , Marine Ecology & Aquaculture
Marine Ecology & Aquaculture
+64-3-343 7855
p.sagar@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
10 Kyle Street
Riccarton
Christchurch 8011
PO Box 8602, Riccarton
Christchurch 8440
New Zealand

Phone +64-3-348 8987
Fax +64-3-348 5548

NIWA Client Report No: CHC2014-038
Report date: May 2014
NIWA Project: DOC13301

Contents

Tables

Figures

Reviewed by

David Thompson

Approved for release by

John Zeldis

Executive summary

Counts of nests in photographs taken during the period 2006-2012 were compared to those reported for the period 1940s to 1997 by Moore (2004) for grey-headed albatross (*Thalassarche chrysostoma*) and Campbell albatross (*T. impavida*) at Campbell Island. Photographs of known colonies were taken from established long-term photopoints during late October and early November in both 2011 and 2012. Following downloading to a PC the numbers of apparent occupied nests in specific count areas described in detail by Moore & Blezard (1999) were counted and added to a spreadsheet of counts provided by the Department of Conservation. Trends in the numbers of the two species of albatross were analysed using the TRIM software, with data inputted separately for colonies dominated by grey-headed albatrosses and Campbell albatrosses.

The results indicated uncertain trends for both species for the period 1995-97 to 2006-2012, with estimated numbers of grey-headed albatrosses showing a non-significant increase and those of Campbell albatrosses a non-significant decrease. However, with counts in just 1-2 years during the period 2006-2012 and grey-headed albatross being a biennial-breeding species it is probably prudent not to put too great a confidence in the trends until more data are recorded.

Assuming that the proportions of each species have remained similar to those estimated in 1995-97 at all colonies then the total number of annual breeding pairs of grey-headed albatross was estimated at 8,611 pairs and that of Campbell albatrosses at 21,648 pairs for the period 2006-2012.

1 Introduction

The Campbell albatross (*Thalassarche impavida*) is endemic to New Zealand and breeds only at Campbell Island (52°32'S, 169°08'E) and its offshore Isle de Jeanette Marie. Campbell Island is also the only New Zealand breeding site of the grey-headed albatross (*T. chrysostoma*), which otherwise has a circumpolar breeding distribution around the Southern Ocean (Gill et al. 2010). These species of albatross form mixed breeding colonies (Figure 1-1) and have a similar breeding season (Sep-Apr). Campbell albatrosses have been reported as bycatch in a number of fisheries operating within the New Zealand Exclusive Economic Zone, mainly in surface long-line fisheries and trawl fisheries, but there have been very few observed captures of grey-headed albatrosses in New Zealand commercial fisheries (Richard et al. 2011). Despite the differences in the occurrence of these two species of albatross in the bycatch the risk ratio of both species is high (Richard et al. 2011), and substantial declines in their breeding populations have been documented (Waugh et al. 1999; Moore 2004).

Figure 1-1: Nesting Campbell albatrosses and grey-headed albatrosses at Bull Rock South, Campbell Island, October 2011.

Counts of occupied nests in photographs taken since the 1940s plus ground counts completed during the 1990s were used by Moore (2004) to estimate population trends over a 55-year period (1942-1997). During this period there were apparent continuous decreases in the numbers of breeding grey-headed albatrosses of 82-88% (at 1.5%-2.7% per annum), based on three colonies with the longest photographic record. Changes in the numbers of breeding Campbell albatrosses were more variable during the same period, with nest numbers in one colony apparently increasing by 11% between the 1940s and 1966, before declining 47% by the 1980s, and then a gradual recovery 3.2% per annum through to 1997. A separate demographic study carried out between 1984 and 1994 by Waugh et al. (1999) also indicated that the long downward trend in numbers of grey-headed albatross continued into the 1990s, whilst numbers of Campbell albatrosses had increased at average rates of 1.1% and 2.1% at two colonies since at least 1984. Modelling of demographic parameters indicated that grey-headed albatross numbers would continue to decline (Waugh et al. 1999). Both Waugh et al. (1999) and Moore (2004) attributed the decline in grey-headed albatross numbers to natural environmental processes, whilst the trends in Campbell albatross numbers were contemporaneous with the development and then reduction of long-line and trawl fisheries in the foraging range of these birds.

The purpose of this report is to determine the population size and trend of breeding Campbell albatrosses and grey-headed albatrosses on Campbell Island based on photographs taken in October 2012 from each of 12 photo-points established by Moore (2004). This project (POP2012-04) was funded by the Conservation Services Levy, administered by the Department of Conservation. However, for the sake of completeness and to give added support for the analysis, counts made from photographs taken from each of the photo-points MP1-MP12 and photo-view C1 during October-November 2011 are also included.

2 Methods

2.1 Photographs

Population estimates were made using counts of occupied nests (i.e. nests on which an albatross was sitting) detected in photographs. Digital photographs were taken from the 12 standard photo-points labelled MP1-MP12 in Figures 2-4 of Moore (2004) which are reproduced here as Figures 2-1 – 2-3. These photo-points, installed during 1987, were positioned to give views of colonies that were as complete as possible. In addition five of the photo-points repeated views available in historical photographs taken by J. Sorensen in the 1940s (Moore 2004). The large and inaccessible colonies of Courrejolles Peninsula were photographed from photo-view C1 using a telephotos lens.

Unfortunately, weather conditions prevented photographs being taken from all photo-points on the same day or even consecutive days. In 2011, photographs were taken from MP2 to MP12 between 1000 h and 1500 h on 28 October, and from C1 and MP1 between 1000 h and 1200 h on 7 November. In 2012, photographs were taken from MP5 to MP11 on 28 October, MP12 on 4 November, and C1 and MP1 to MP4 on 6 November. In both years, both species of albatross were about the middle of their incubation stage.

2.2 Ground counts

To determine the proportion of birds in the colonies that were not on a nest, a ground count of occupied nests and birds present was completed between 1000 h and 1300 h on 26 October 2011. This was completed in a section of the Bull Rock South colony between the Study Square and photo-point MP10. In this area all occupied nests were sprayed with stock marker as they were counted to avoid double counting. In addition, an attempt was made to count and, where possible, lightly spray with stock marker, all loafing birds (i.e. those on the ground within the area, but not incubating). A check of this area for unmarked nests was made the following day, but none was located.

2.3 Counting

Following downloading of the digital photographs to a PC albatrosses were counted individually on one image displayed on the computer screen in Paint.NET. Limits of colonies and counting areas were determined following close inspection of photographs and Figures in a digital copy of Moore & Blezard (1999) and the boundaries of each well-defined area were marked with a narrow yellow line. The numbers of nests within each defined area were estimated, with each nest being marked by a yellow dot as it was counted. In all photographs the basic unit for counting purposes was a bird on a nest (Moore 2004). Where it was possible to distinguish standing birds or partners at a nest, these extra birds were marked off, but omitted from the count.

Because some photographs varied in their field of view (for example, due to whether or not the photographer stood on a rock or clump of tussock at a photo-point to take the photographs) it was necessary to further subdivide areas based on geographic features (Moore & Blezard 1999). To maintain comparability of counts, in this report I follow the photo-views, boundaries for counting purposes, and the subtotal areas detailed in Moore & Blezard (1999).

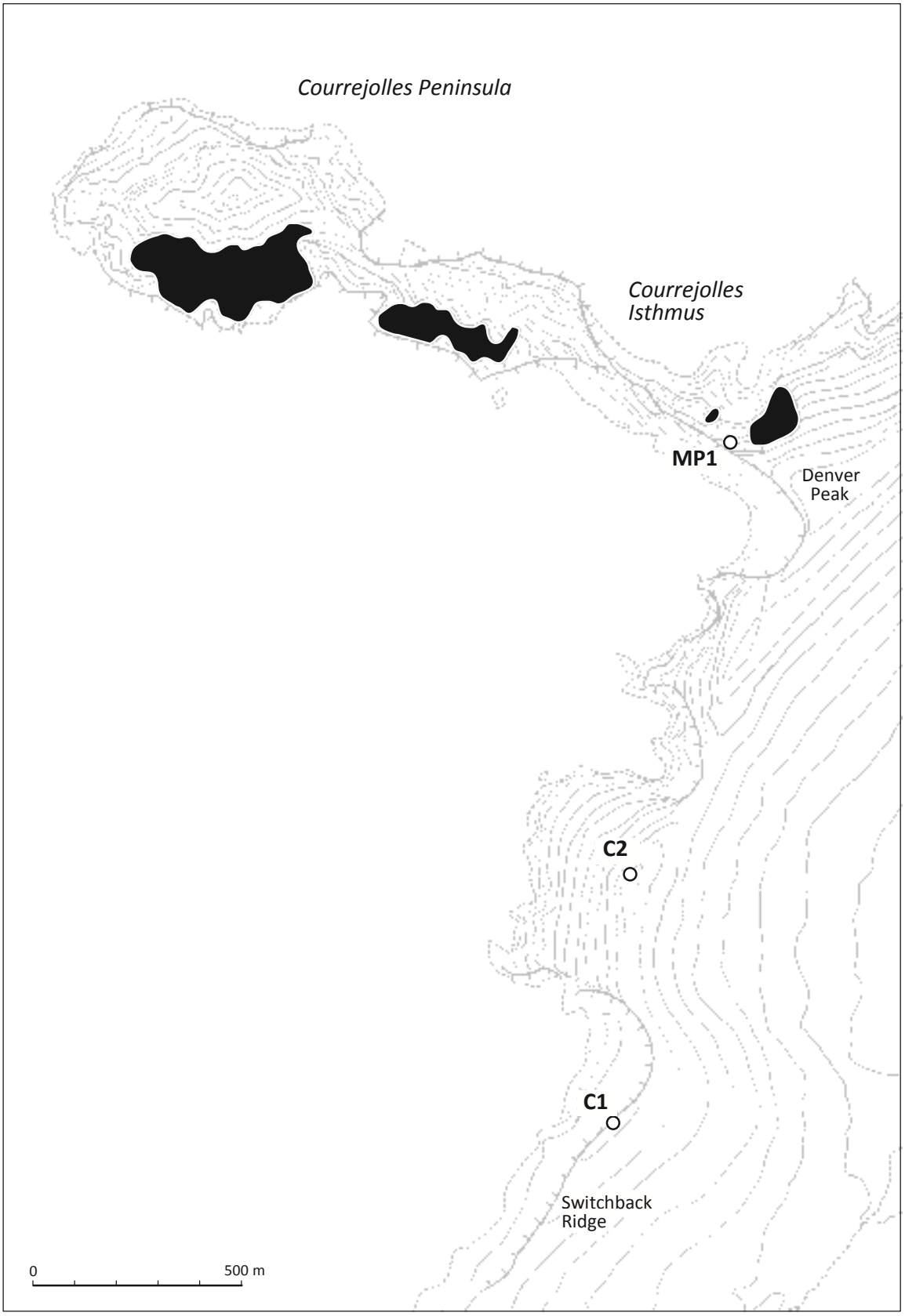

Figure 2-1: Courrejolles Peninsula, Campbell Island, showing approximate extent of albatross colonies (black), location of photo point MP1 and photo-view point C1. Figure taken from Moore (2004).

Hookers Peninsula.

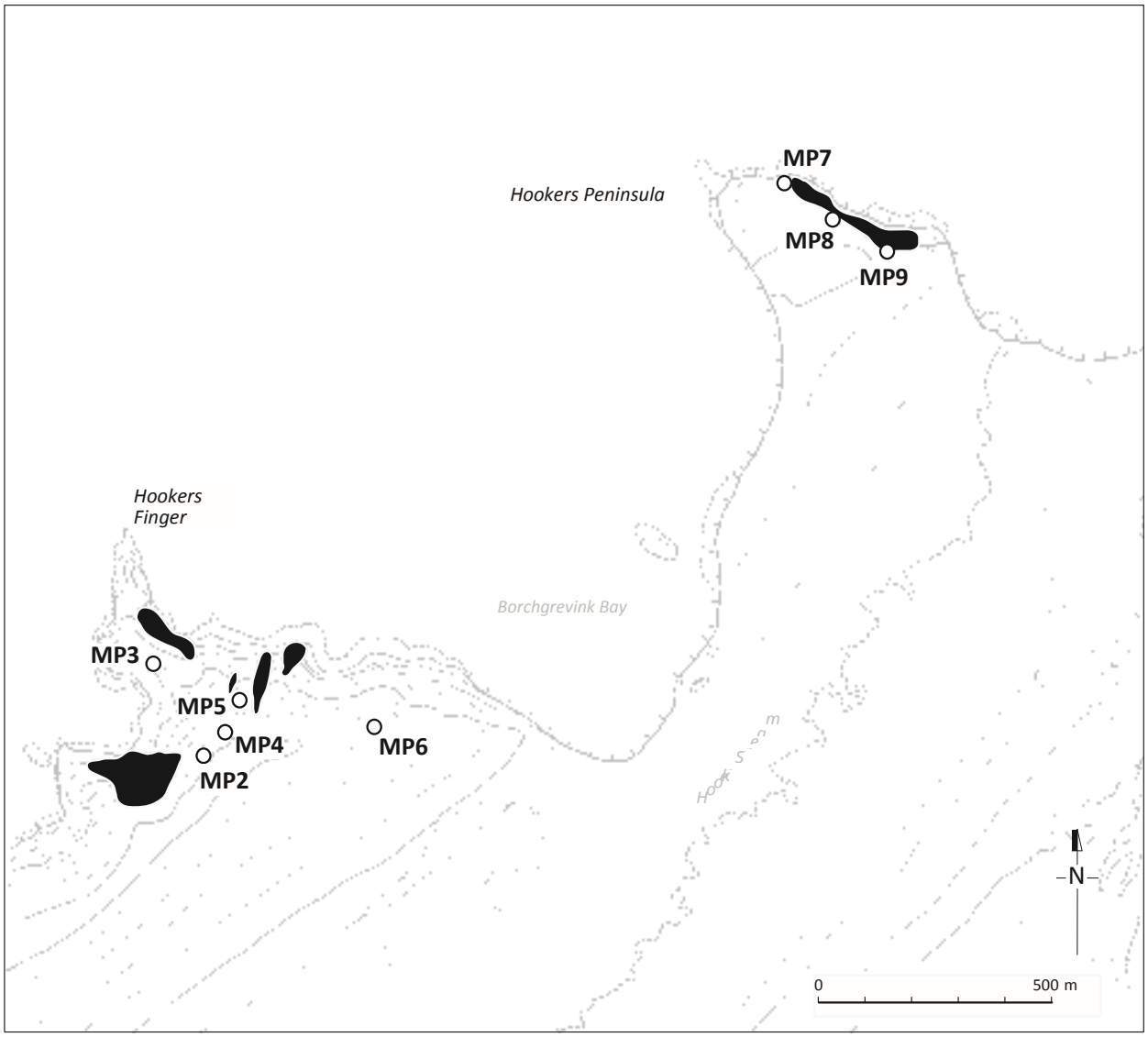

Figure 2-2: Hookers Finger and Hookers Peninsula, Campbell Island, showing approximate extent of albatross colonies (black) and location of photo-points MP2-9. Figure taken from Moore (2004).

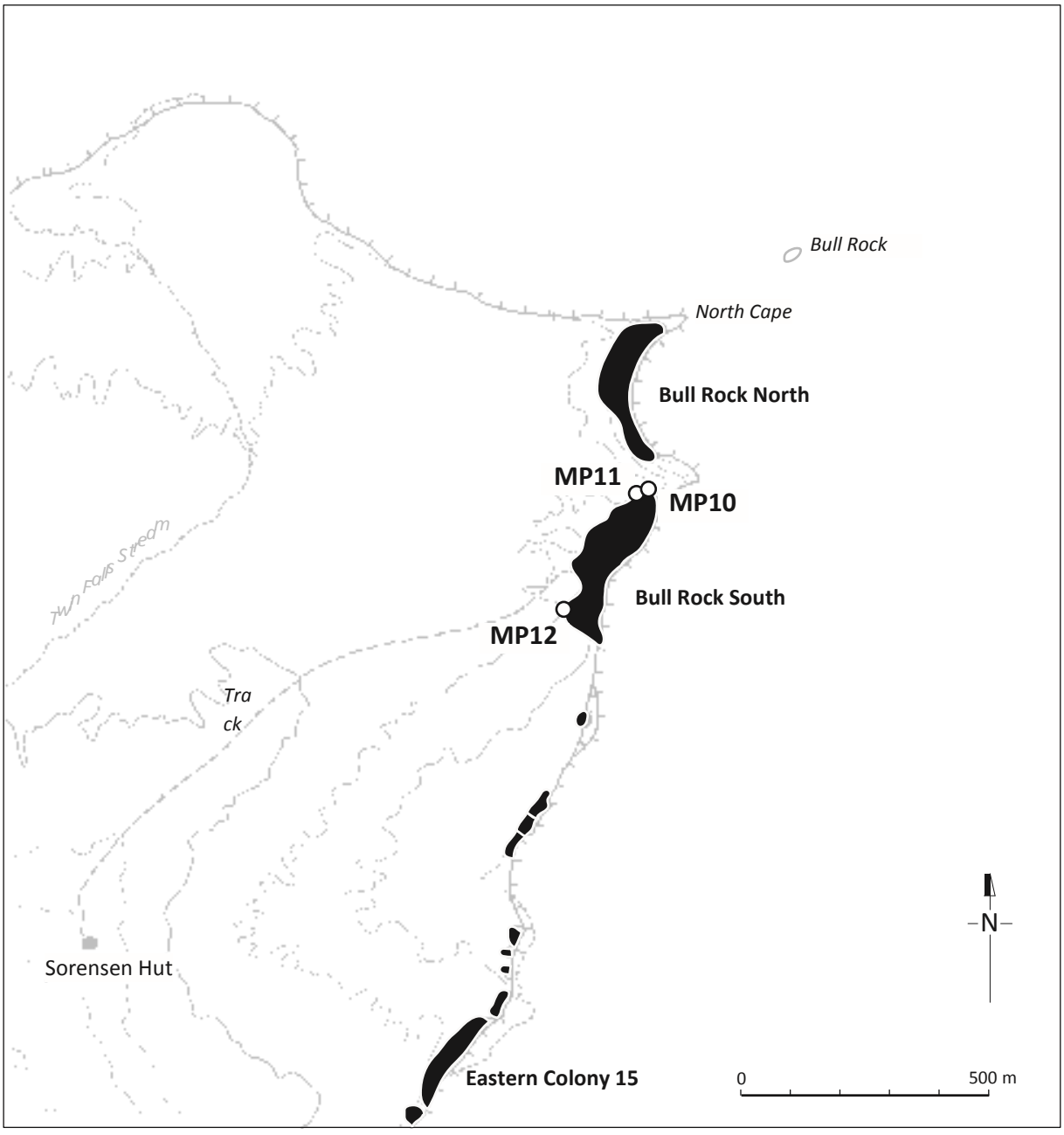

Figure 2-3: Bull Rock, Campbell Island, showing approximate extent of albatross colonies (black) and location of photo-points MP10-12. Figure taken from Moore (2004).

Counting of birds in the photographs was undertaken by one observer only, with duplicate counts of most areas to ensure consistency. Previously, Baker et al (2011) had undertaken multiple counts of photomontages from and an aerial survey of white-capped albatrosses (*Thalassarche steadi*) on the Auckland Islands to estimate counter variability associated with miscounting and misidentifying white spots on the ground. These count data were modelled statistically by Poisson regression, a specialised case of a Generalised Linear Model (McCullagh & Nelder 1989), with observer and area fixed effects. The results showed no evidence to suggest that the model and the data were incompatible, nor was there any evidence of a difference between observers and hence observer bias. I have no reason to

believe that data collected from Campbell Island should have different distributional properties to Baker et al (2011), and so assume my data are compatible with a Poisson model. Therefore, I present raw counts only and assume the deviation is estimated as the square root of the count, a property of the Poisson model.

2.4 Data

Data were transferred to an Excel spreadsheet for each photo-point and added to the consolidated spreadsheet of albatross counts from Campbell Island which was sourced from Department of Conservation files by Igor Debski. This spreadsheet included not only the data reported by Moore (2004), but also counts made from photographs taken from some of the standard photo-points and photo-view C1 during the period 2004-2008. Therefore, in addition to the published counts (Moore 2004) these previously unpublished counts are used, where appropriate, in this report when assessing population trends.

2.5 Trend analysis

Trend analyses were run using software program TRIM (Trends and Indices for Monitoring Data; Pannekoek & van Strien 1996). TRIM was developed by Statistics Netherlands and is a standard tool used to analyse populations trends e.g., by the Agreement for the Conservation of Albatrosses and Petrels (ACAP). Following Baker et al. (2011), the linear trend model with stepwise selection of change points (missing values removed) was used with serial correlation taken into account but not over-dispersion. Overall population trends for each species were analysed by combining the time-series with missing observations and making a log-linear regression model with Poisson error terms (DeLord et al. 2004; Baker et al. 2011). Population size estimates and their standard errors obtained from the TRIM analyses were used to obtain the overall estimated breeding numbers for each species at each photopoint site. Changes in population trends across years were examined by modelling change points at each time point, followed by the stepwise selection procedure to identify change points with significant changes in slope based on Wald tests with a significance threshold of 0.01 (Pannekoek & van Strien 1996). Over-dispersion and serial correlation was taken into account because they can have important effects on standard errors, although they usually only have a small effect on the estimates of parameters (Pannekoek & van Strien 1996). No covariate was used. Annual rates of population change were calculated, for each species, using the relationship:

$$R = \ln \lambda = \ln N_{t+1}/N_t$$

Where Nt and Nt+1 are the numbers of pairs breeding in years t and t+1 respectively (taken to be the numbers of breeding birds counted in year t and t+1, and λ is the population growth rate (Caughley 1980). It was assumed that all nesting birds were detected. Nt+1, Nt and λ were given by TRIM. All population size estimates are presented +/- 1 SE or +/1 95% confidence intervals.

TRIM classifies trends by converting the multiplicative overall slope estimate into one of six categories, depending on the overall slope as well as the 95% confidence interval. The six categories are:

Strong increase – increase significantly greater than 5% per year (5% would result in a doubling of the population within 15 years). Criterion: lower limit of confidence interval >1.05.

Moderate increase – significant increase, but not more than 5% per year. Criterion: 1.00<lower limit of confidence interval<1.05.

Stable – no significant increase or decrease and it is certain that trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit >0.95 and upper limit <1.05.

Uncertain – no significant increase or decrease, but not certain if trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit <0.95 and upper limit >1.05.

Moderate decline: significant decrease, but not significantly more than 5% per year. Criterion: 0.95 < upper limit of confidence interval <1.00.

Steep decline – decrease significantly more than 5% per year (5% would mean halving the abundance within 15 years). Criterion: upper confidence interval <0.95.

3 Results

The totals from photographs presented below follow the same sequence described in Moore (2004), following the order of the standard photopoint series (MP1-12). Zones within each of these photopoints also follow the definitions provided by Moore (2004). The species composition of each of these zones is derived from field work completed in 1995-1997 (Moore 2004). Results from the inaccessible colonies of the Courjolles Peninsula are presented at the end of the Results section.

3.1 Ground counts

The ground counts at Bull Rock South indicated that the proportions of breeding birds in the colony between 1000 and 1300 h was 92.2% and 90.1% for Campbell albatross and grey-headed albatross, respectively (Table 3-1).

Table 3-1: Results of ground count completed at Bull Rock South (in part), 26 October 2011.

	Nest + egg	Loafer	Total	% loafers
Campbell Albatross	1074	91	1165	7.8
Grey-headed Albatross	73	8	81	9.9

3.2 MP1 (Courrejolles Isthmus)

Courejolles Isthmus is a small accessible colony at the base of Courejolles Peninsula, where virtually all the breeding birds are grey-headed albatrosses (Moore 2004). The number of nests declined by 88.5% between 1945 and 1995-97 and the area occupied also declined (Moore 2004). However, the decline appears to have stopped subsequently (Figure 3-1, Table 3-2), with numbers fluctuating widely (between 60 and 185, at JDK subcolony; Figure 3-2), which is typical of biennial breeding species, such as grey-headed albatross.

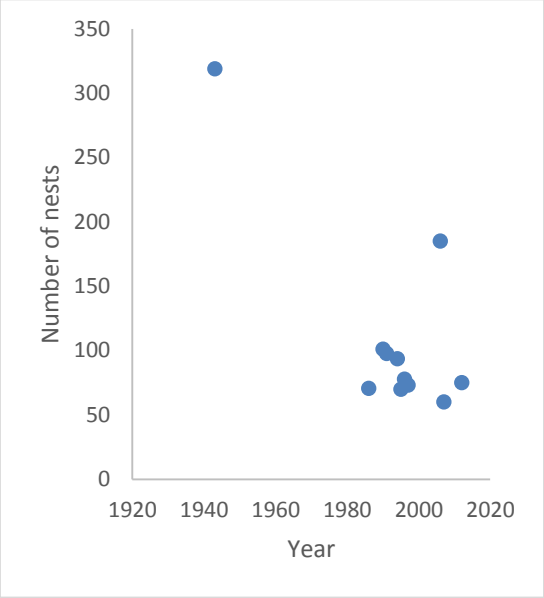

Figure 3-1: Trend in numbers of nests estimated in mid October at count zone T60, Courrejolles Isthmus photopoint JDK. Data from 1943-1997 from Moore (2004) and 2007-08 from DOC datafile.

3.3 MP2 (Hookers Finger)

Photopoint MP2 provides views of another colony composed mainly of grey-headed albatrosses (Moore 2004). This colony also showed a massive decrease in numbers of occupied nests, declining 79% between 1942 and 1995-97 (Moore 1942). However, the most recent photographs indicate that the decline has stopped and that numbers have remained relatively similar during the period 1990-2012 (Figure 3-2, Table 3-2).

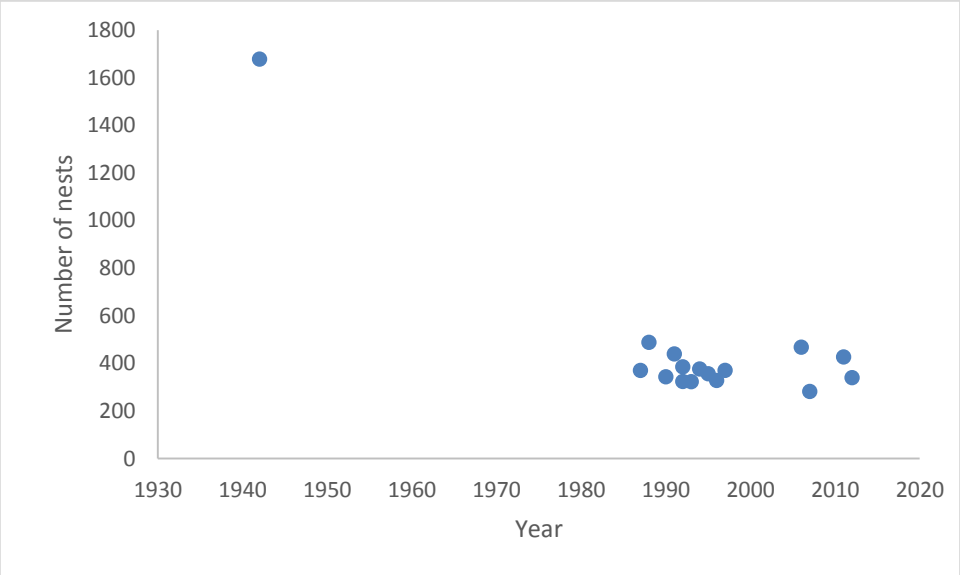

Figure 3-2: Trend in numbers of nests estimated in mid October at count zone T13, Hookers Finger photopoint MP2. Data from 1943-1997 from Moore (2004) and 2007-08 from DOC datafile.

Table 3-2: Estimated mean numbers of nests at colonies dominated by grey-headed albatrosses from different periods 1940s-2012. Data from 1940s to 1997 from Moore (2004). ND, no data.

Photopoint-Count Zone	1940s	1980-84	1985-89	1990-94	1995-97	2006-2012
MP1-T60	313	ND	70	97	72	107
MP2-T13	1678	ND	400	355	352	379
MP3a-T17	2586	581	532	419	450	576
MP4-T24	698	ND	162	164	144	325
MP7-T27	ND	ND	381	478	453	375
MP8-T29	ND	ND	126	100	78	72
MP9-T31	ND	ND	239	231	187	145

3.4 MP3 (Hookers Finger)

Colony 3, visible from photopoint MP3 is also dominated by grey-headed albatrosses and showed a decrease of nearly 80% between 1942 and 1995-97 (Table 3-2; Moore 2004). However, as with colony 2 numbers of occupied nests appear to have remained similar between 1980-84 and 2006-2012 (Table 3-2, Figure 3-3).

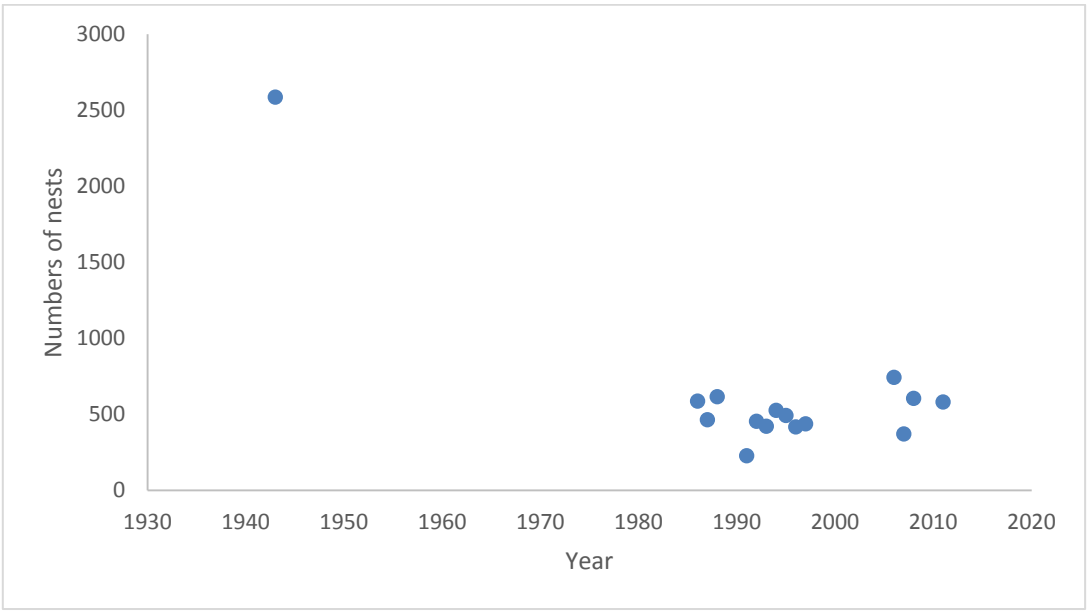

Figure 3-3: Trend in the numbers of nests estimated in mid October at count zone T17, Hookers Finger colon y MP3a, 1943-2011. Data from 1943-1997 from Moore (2004) and 2007-08 from DOC datafile.

3.5 MP4 (Hookers Finger)

As with other colonies that are composed mainly of grey-headed albatrosses the numbers of occupied nests exhibited a sharp decline between 1942 and 1986 (Table 3-2, Figure 3-4). However, by 2006 numbers had increased to the extent that the average number of occupied nests 2006-2012 was about twice that recorded 1995-97 (Table 3-2).

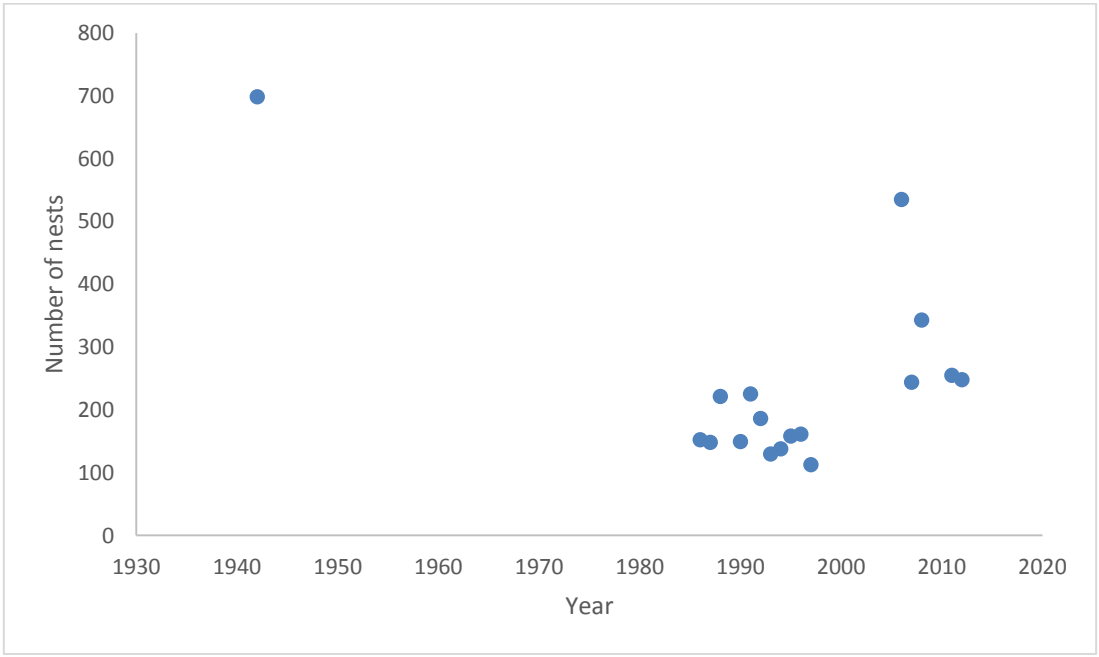

Figure 3-4: Trend in numbers of nests estimated in mid October at count zone T24, Hookers Finger photopoint MP4. Data from 1943-1997 from Moore (2004) and 2007-08 from DOC datafile.

3.6 MP5 (Hookers Finger)

This colony was composed mainly of Campbell albatrosses during ground counts in 1995-97 (Moore 2004). Counts from photographs taken in the 1980s and 1990s showed the numbers of occupied nests declining at a rate of 1.3% per annum (Moore 2004), and this decrease has continued into the period 2006-2012, with numbers declining a further 23% between 1995-97 and 2006-11 (Table 3-3, Figure 3-5).

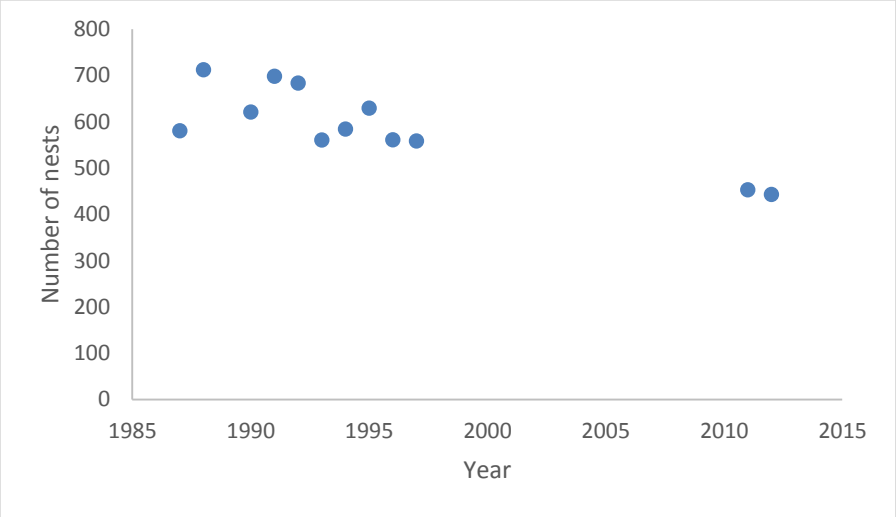

Figure 3-5: Trend in numbers of nests estimated in count zone T25 during mid October at Hookers Finger colony photopoint MP5. Data from 19878-1997 from Moore (2004).

3.7 MP6 (Hookers Finger)

In 1995-97, 73% of the nests in this colony were occupied by Campbell albatrosses (Moore 2004). Here the numbers of occupied nests declined 0.6% per annum between 1987 and 1997 (Moore 2004) and nearly 0.4% per annum between 1995-97 and 2006-2012 (Table 3-3, Figure 3-6).

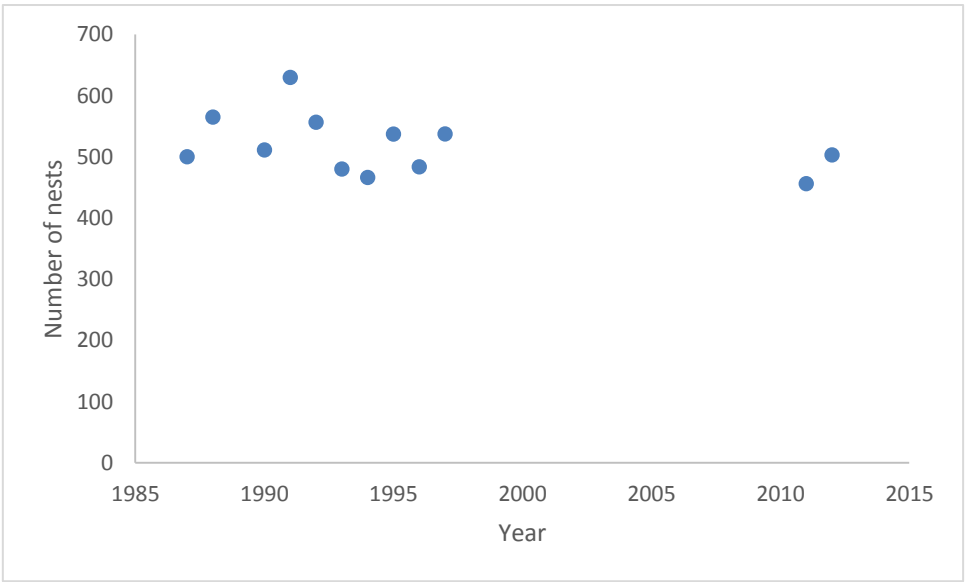

Figure 3-6: Trend in numbers of nests estimated in count zone T26 during mid October at Hooker's Finger photopoint MP6. Data from 1987-1997 taken from Moore (2004).

3.8 MP7 (Hookers Peninsula)

The western subcolony on Hookers Peninsula was composed of 73% grey-headed albatrosses in 1995-97 (Moore 2004).During the period 1987-1997 there were wide fluctuations in the numbers of occupied nests and overall there was an increase in numbers of 1.2% per annum (Moore 2004). However, there was an apparent decline in numbers through the 1990s and this has continued through to 2007-2011 (Table 3-2, Figure 3-7).

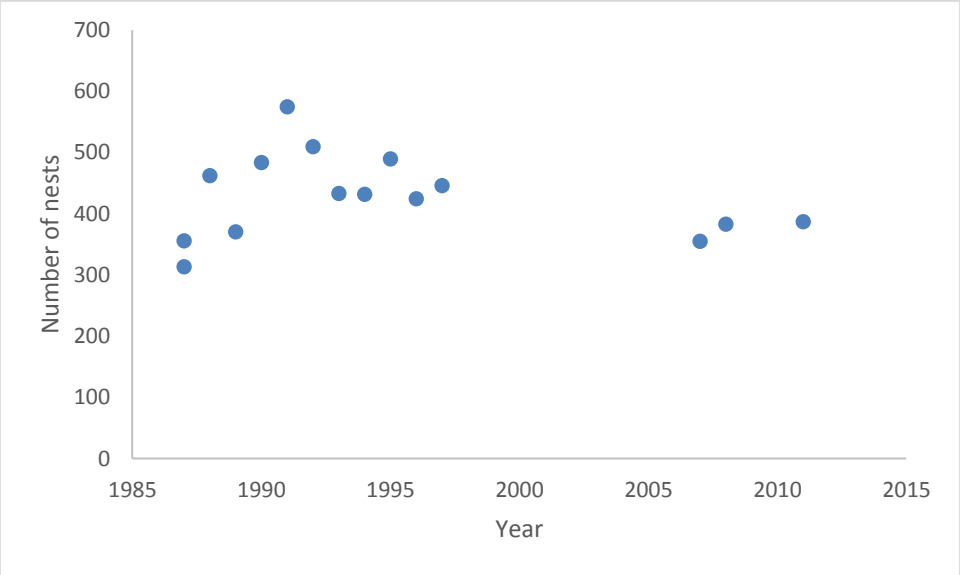

Figure 3-7: Trend in numbers of nests estimated in mid October at count zone T27, Hookers Peninsula photopoint MP7. Data from 1987-1997 from Moore (2004).

3.9 MP8 (Hookers Peninsula)

The peripheral colonies of Hookers Peninsula were also dominated by grey-headed albatrosses and showed a steady decline (averaging 4.1% per annum during the 1980s and 1990s (Moore 2004). Numbers have fluctuated widely 2007-2012 (Figure 3-8), with the average number of occupied nests counted differing little from that recorded 1995-97 (Table 3-2).

3.10 MP9 (Hookers Peninsula)

The downward trend (-2.5% per annum) from 1987 to 1997 continued through to 2012 (Table 3-2, Figure 3-9).

3.11 MP10 (Bull Rock South)

This is a large accessible colony with 95% of nests occupied by Campbell albatrosses in 1995-97. Photographs of the central and lower terraces taken from the northern end of the colony during the 1980s and 1990s showed a slight increase in the numbers of occupied nests, although there were wide annual fluctuations (Figure 3-10, Moore 2004). The 565 occupied nests counted in 2011 represents a decline of 14.6% over the 650 occupied nests counted in 1997. However, it is similar to the 581 nests counted in 1990.

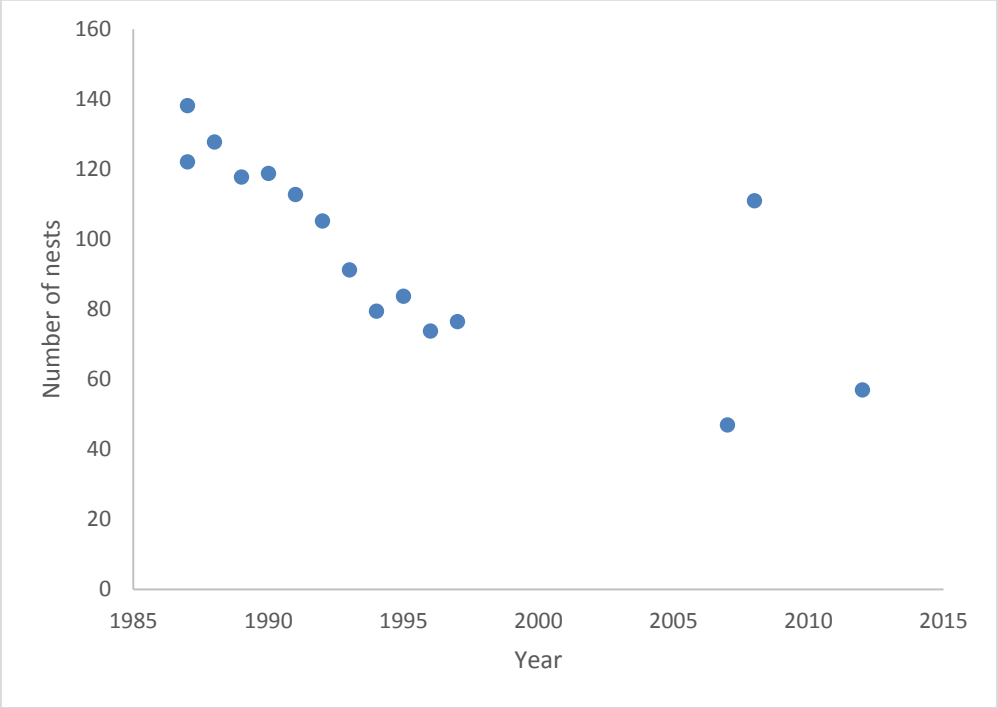

Figure 3-8: Trend in numbers of nests estimated from mid October at count zone T29, Hookers Peninsula photopoint MP8. Data from 1987-1997 from Moore (2004) and 2007-08 from DOC datafile.

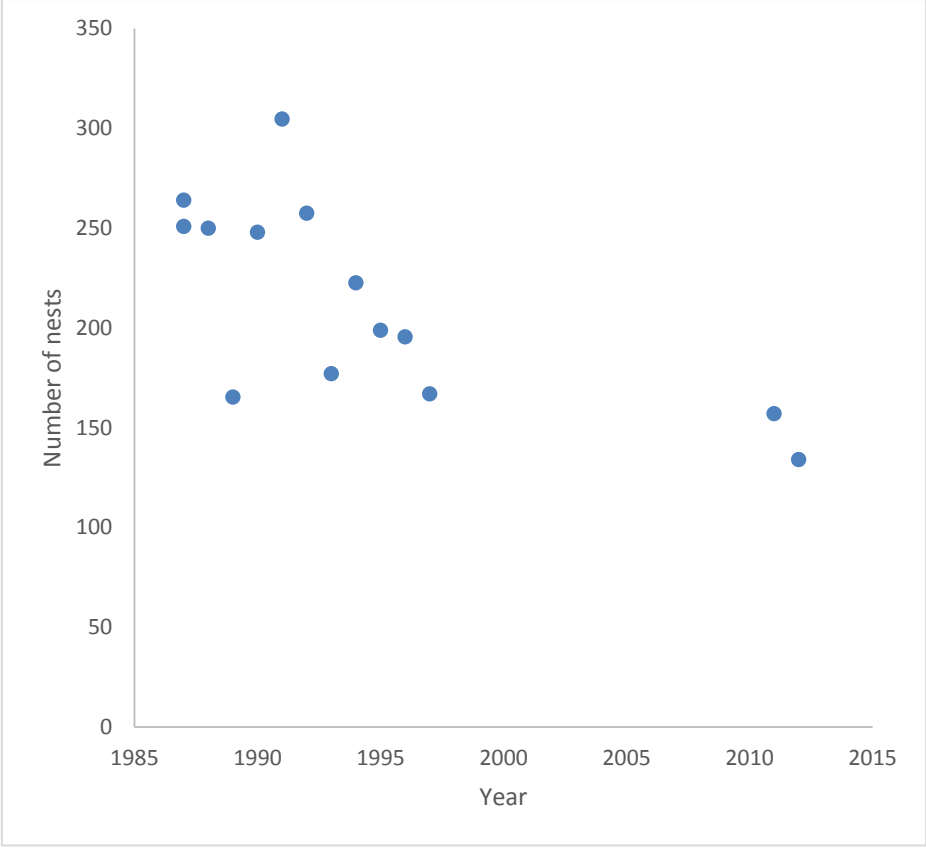

Figure 3-9: Trend in numbers of nests estimated in count zone T31 during mid October at Hookers Peninsula photopoint MP9. Data from 1987-1997 taken from Moore (2004).

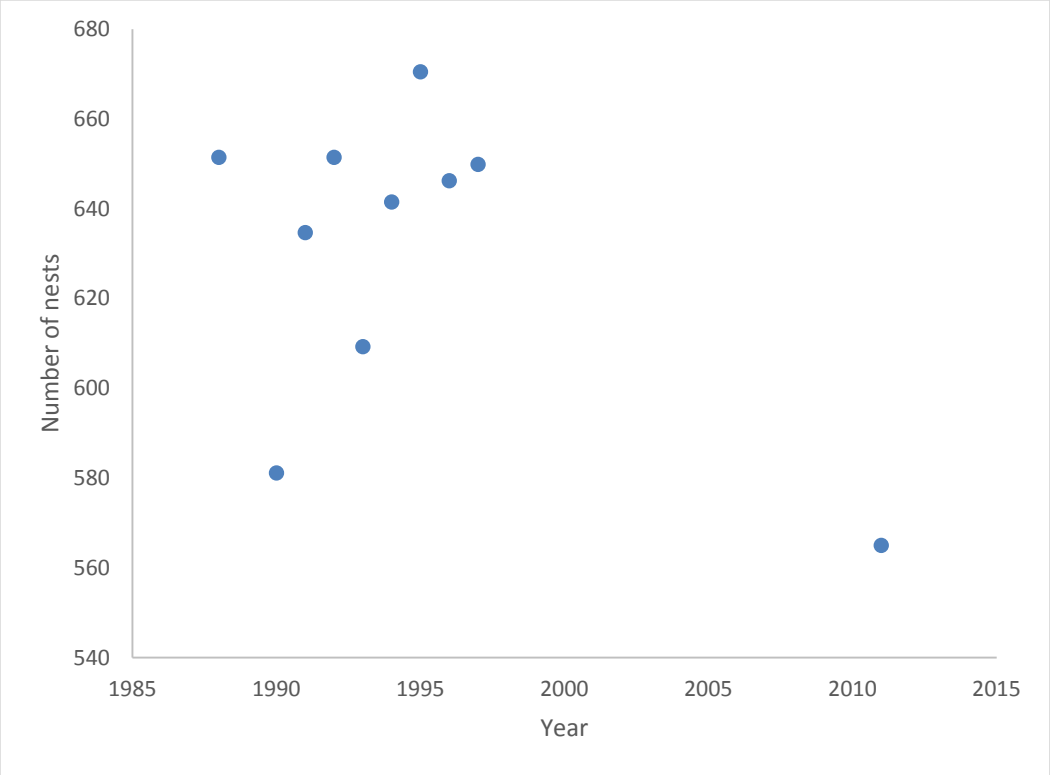

Figure 3-10:Trend in the numbers of nests estimated in count zone T33 during mid October at Bull Rock South, 1986-2011. Data from 1986-1997 taken from Moore (2004).

3.12 MP11 (Bull Rock North)

Photopoint MP11 is a vantage point about 250 m from the Campbell albatross-dominated Bull Rock North colony, but provides an unobstructed view of most of the colony, which is composed mainly of Campbell albatrosses (Moore 2004). With six photographs taken before 1986 and annually 1987 to 1997 this colony has the best photographic series of any on Campbell Island (Moore 2004). The five photographs taken 2007-2012 indicate that the apparent increase in the numbers of nests from the 1980s through to 1997 has continued, with a mean of 3507 estimated number of nests during the period 2007-2011compared to 2911 for 1995-1997 (Table 3-3, Figure 3-11), an increase of 20% (1.7% p.a).

Table 3-3: Estimated mean numbers of nests at colonies dominated by Campbell albatrosses from different periods 1940s-2012. Data from 1940s to 1997 from Moore (2004). ND, no data.

Photopoint-Count Zone	1940s	1960s	1970s	1980-84	1985-89	1990-94	1995-97	2006-12
MP5-T25	ND	ND	ND	ND	668	630	583	448
MP6-T26	ND	ND	ND	ND	543	521	519	479
MP11-T41	3709	3721	ND	2200	2281	2654	2911	3507
MP10-T33	ND	ND	ND	ND	651	624	656	565
MP12-T47	ND	ND	737	665	747	753	871	850
C1-T53/54	ND	10,665	8397	8317	8278	8495	8102	6154

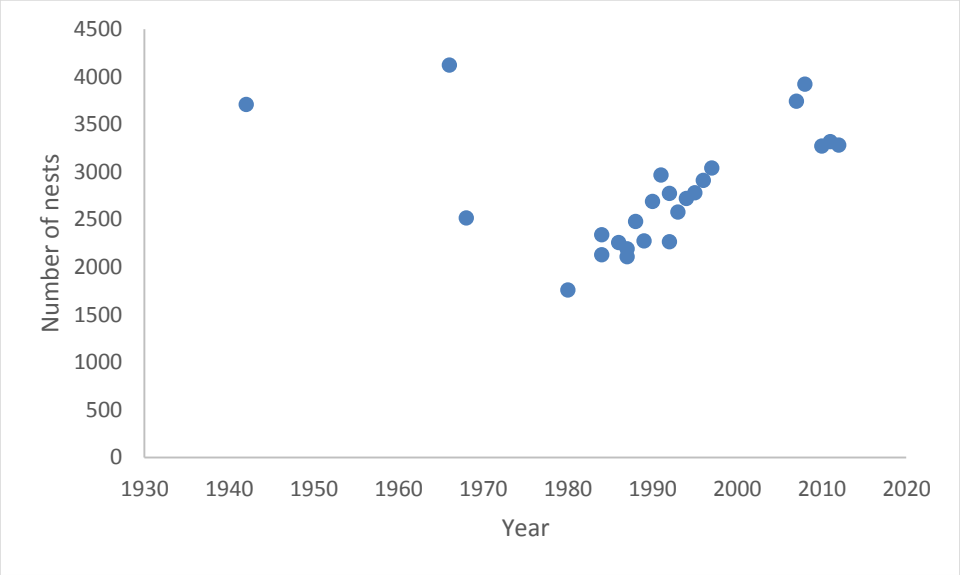

Figure 3-11:Trend in the numbers of nests estimated in count zone T41 during mid October at Bull Rock North, 1943-2012. Data from 1943-1997 taken from Moore (2004) and 2007-2008 from DOC datafile.

3.13 MP12 (Bull Rock South)

The numbers of occupied nests fluctuated widely from year to year, but overall showed an increasing trend (Table 3-3, Figure 3-12).

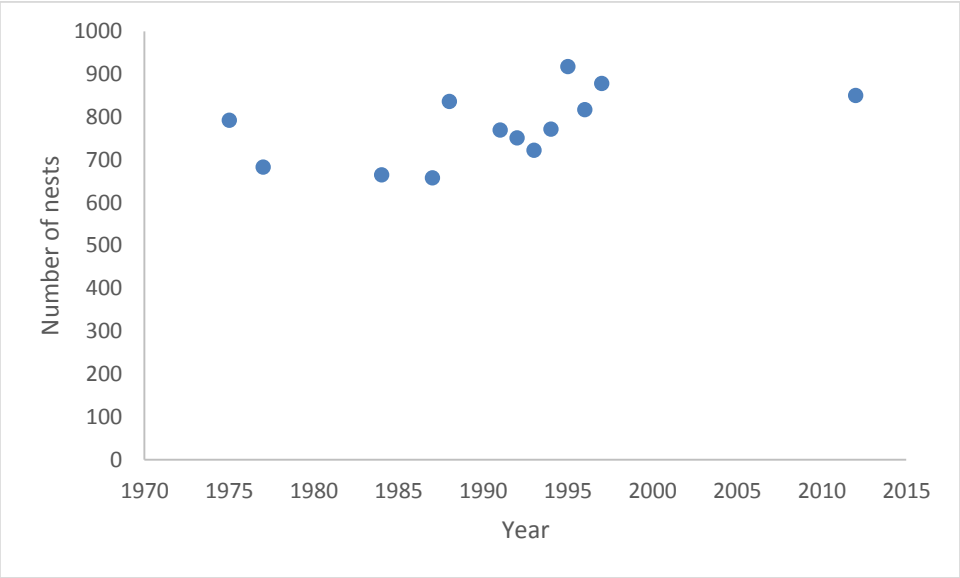

Figure 3-12:Trend in the numbers of nests estimated in count zone T47 during mid October at Bull Rock South, 1975-2012. Data from 1975-1997 taken from Moore (2004).

3.14 Courrejolles Peninsula

There are several large, inaccessible colonies on the southern slopes of Courrejolles Peninsula, which were estimated to comprise 67% Campbell albatross and 33% grey-headed albatross in 1995-97 (Moore 2004). The approximately 2 km distance from the photopoints to the colonies combined with less than ideal atmospheric conditions make

counting less precise than for other colonies. However, with the central colonies more or less at right angles to the photopoint it is possible to obtain relatively unobstructed views (Moore 2004). The average count for 2007-2011 was 6154 nests, compared to 8102 from the same colonies in 1995-1997 (Table 3-3, Figure 3-13), a decrease of 24% (2% p.a).

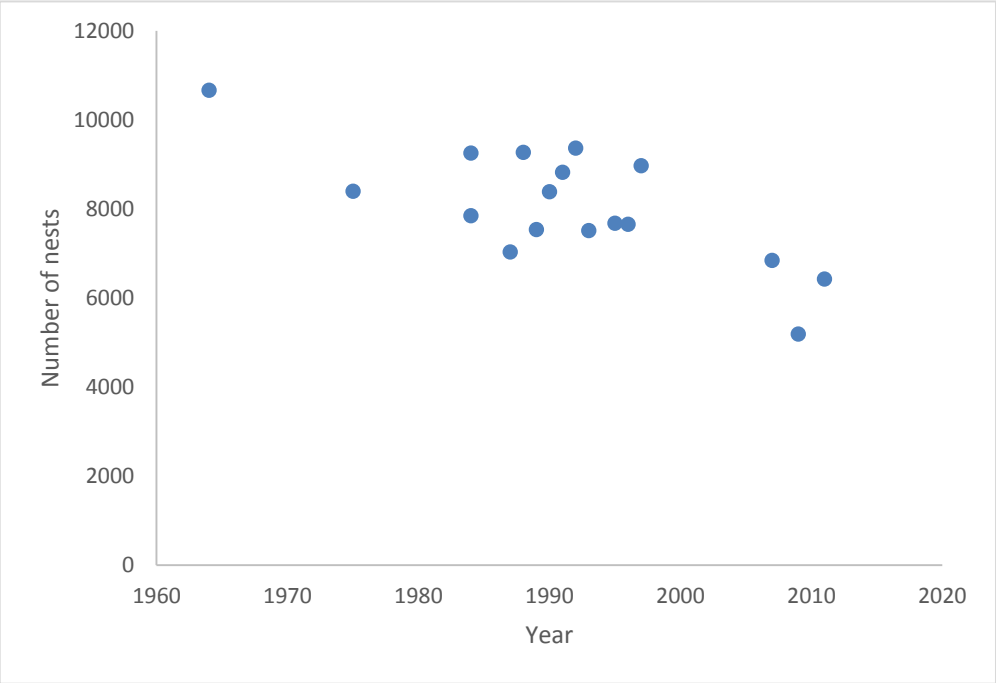

Figure 3-13:Trend in the numbers of nests estimated during mid October in count zones T53/54, Courrejolles Peninsula, 1964-2011. Data from 1964-1997 taken from Moore (2004) and 2007-2009 from DOC datafile.

3.15 Overall population trends

Combining the counts from the grey-headed albatross-dominated colonies (Table 3-2) indicates that the population increased 14% between 1995-97 and 2006-2012, with estimated totals of 1736 and 1979 occupied nests respectively. In contrast, the total from Campbell albatross-dominated colonies decreased 12% in the same period, from 13,642 to 12,003 occupied nests (Table 3-3).

TRIM is able to account for sites where data are not available in all years, and so data from Tables 3-2 and 3-3, plus estimated counts for all sites combined were used as inputs to the TRIM model for assessment of population trend.

For all sites listed in Table 3-2 combined, the population size estimates of colonies dominated by grey-headed albatrosses computed from the TRIM analysis indicate a steep decline for the period 1940s-2012. However, for the latest period (1995-2012) the trend was uncertain but indicated a non-significant increase (Table 3-4). Population trends varied in colonies dominated by grey-headed albatrosses during 1995-2012, with some increasing and others decreasing (Table 3-4).

Table 3-4: Results of TRIM model analysis of population trends in grey-headed albatrosses at Campbell Island for selected count zones and time periods. *, p<0.02; **, p<0.01.

Photopoint-Count Zone	Time period	Overall slope imputed	λ ± 1SE	Mean annual decline/increase (%)
All sites combined	1940s-2012	Steep decline*	0.80 ± 0.02	-0.28
MP3a-T17	1980-2012	Uncertain	0.97 ± 0.03	-0.09
All sites combined	1980-2012	Stable	0.98 ± 0.01	-0.06
MP1-T60	1995-2012	Moderate increase*	1.49 ± 0.22	2.70
MP2-T13	1995-2012	Uncertain	1.08 ± 0.08	0.43
MP3a-T17	1995-2012	Strong increase**	1.28 ± 0.08	1.56
MP4-T24	1995-2012	Strong increase**	2.26 ± 0.22	6.98
MP7-T27	1995-2012	Steep decline*	0.83 ± 0.06	-0.96
MP8-T29	1995-2012	Uncertain	0.92 ± 0.15	-0.43
MP9-T31	1995-2012	Steep decline*	0.78 ± 0.09	-1.25
All sites combined	1995-2012	Uncertain	1.14 ± 0.17	0.78

Likewise, in colonies dominated by Campbell albatrosses, the TRIM analysis indicate a moderate decline for all sites combined during the period 1940s-2012. However, for the period 1995-2012 the trend was uncertain but indicated a non-significant decrease (Table 3-5). With the notable exception of the Bull Rock colonies, most colonies dominated by Campbell albatrosses declined during the period 1995-2012 (Table 3-5).

Table 3-5: Results of TRIM model analysis of population trends in Campbell Albatrosses at Campbell Island for selected count zones and time periods. *, p<0.05; **, p<0.01.

Photopoint-Count Zone	Time period	Overall slope imputed	λ ± 1SE	Mean annual decline/increase (%)
All sites combined	1940s-2012	Moderate decline**	0.95 ± 0.01	-0.67
MP12-T47+C1-T53/54	1970s-2012	Moderate decline*	0.96 ± 0.01	-0.87
MP5-T25	1995-2012	Steep decline**	0.77 ± 0.05	-1.28
MP6-T26	1995-2012	Uncertain	0.92 ± 0.06	-0.43
MP10-T33	1995-2012	Moderate decline**	0.86 ± 0.05	-0.77
MP11-T41	1995-2012	Strong increase**	1.20 ± 0.03	1.14
MP12-T47	1995-2012	Uncertain	0.98 ± 0.05	-0.13
C1-T53/54	1995-2011	Steep decline**	0.76 ± 0.01	-1.33
All sites combined	1995-2012	Uncertain	0.88 ± 0.09	-0.67

3.16 Overall population estimate

For each species the changes for all sites combined during the period 1995-2012 (Table 3-4, 3-5) and the estimated annual numbers of nests from 1990-94 (Table 11 in Moore 2004) were used to produce annual estimates of 8,611 grey-headed albatross nests and 21,648 Campbell albatross nests during the period 2006-12. This assumes that the proportion of each species in all colonies combined has not changed significantly since that estimated in 1995-97 by Moore (2004).

4 Discussion

The results of this study indicate that after long-term and apparently continuous declines in the numbers of occupied nests, during the period 1995-97 to 2006-2012 the numbers of grey-headed albatrosses breeding each year probably increased slightly while those of Campbell albatrosses likely decreased slightly though neither trend was significant. However, with counts in just 1-2 years during the period 2006-2012 and grey-headed albatross being a biennial-breeding species it is probably prudent not to put too great a confidence in the trends until more data are recorded.

4.1 Grey-headed albatross

Counts of nests in photographs of colonies dominated by grey-headed albatrosses at Courrejolles Isthmus (MP1) and Hookers Finger (MP2-6) from the 1940s to 1997 suggested that the population had decreased by 82-88% over 55 years (Moore 2004). Moore (2004) argued that poor breeding success during the 1940s may have resulted in crowded grey-headed albatross colonies if a high proportion of birds was nesting every year rather than following the normal biennial pattern. However, Moore (2004) also noted that the colonies occupied substantially larger nesting areas in the 1940s than the 1990s, thus supporting the likelihood of a decrease in population size.

Moore (2004) reported that at some colonies e.g., Courrejolles Isthmus, the rate of decline slowed from 2.7% per annum from the 1940s to 1.2% per annum for the period 1990-94, but small sub-colonies and peripheral nesting areas continued to disappear in the 1990s. He also noted that during the 1990s the numbers of nests of grey-headed albatrosses decreased at colonies both where they comprised the majority of breeding albatrosses and where they were in the minority.

Grey-headed albatrosses tend to nest on steeper slopes and nest on more inland edges of ledges than do Campbell albatrosses, and so Moore (2004) suggested that large numbers of grey-headed albatrosses may have occupied the extensive slopes of Courrejolles Peninsula. A decline in the numbers of grey-headed albatrosses nesting on this Peninsula could explain the overall (grey-headed albatross plus Campbell albatross combined) decrease in nest numbers and colony area that occurred from the 1960s (Moore 2004). As a result Moore (2004) concluded that this supported the hypothesis that the area from Courrejolles Peninsula to Hookers Peninsula was more important for grey-headed albatrosses during the 1940s than subsequently. Further, a smaller proportional change occurred at the Bull Rock and eastern colonies (Moore 2004).

Although the TRIM analysis for the period 1995-2012 indicates an uncertain trend in the estimated numbers of nesting grey-headed albatrosses, the results show non-significant increases in the numbers of birds nesting at most colonies dominated by this species. This indicates that the decline in numbers is likely to have at stopped and the total number of annual breeding pairs increased from 7,800 in the 1990s to 8,611 in 2006-2012.

4.2 Campbell albatross

Estimates of the numbers of breeding Campbell albatrosses showed varying trends from the 1940s to 1997 (Moore 2004). Counts from photographs of Bull Rock North suggested that the population of Campbell albatrosses decreased by about 22% over the 55 years from the

1940s to the 1990s. However, estimated numbers had increased slightly between the 1940s and the 1960s before a 47% decrease in numbers through the 1970s and 1980s before numbers again increased through to 1995-97. However, the estimated total of 24,600 nests at all colonies combined was still 6,700 fewer than the estimated total for the 1940s (Moore 2004) and the estimated numbers of annual breeding pairs has declined subsequently to 21,648 in 2006-2012.

By 2006-2012 the estimated numbers of Campbell albatross nests again showed decreasing trends in three of six colonies for which the photographic record was adequate, with only the Bull Rock North colony showing a strong increase. Of particular note is the strong decrease estimated in the large Courrejolles Peninsula colony. However, two of the three totals used in the estimate for the period 2006-2012 were from photographs taken in Feb 2007 and Jan 2009 and adjusted to mid-Oct estimates by application of regression equations provided in Table A1.1 of Appendix 1, Moore (2004). These regression equations were derived from detailed observations of breeding success made over several years in the 1990s.It may be that breeding success in 2007 and 2009 was significantly different from that in the 1990s. For example, if breeding success was particularly poor in 2007 and 2009 then the derived numbers would be lower than expected, thus affecting the trend estimated by the TRIM analysis.

Annual variations in breeding success will obviously confound estimates of the total numbers of annual breeding pairs, and so it is strongly recommended that every effort should be made to complete photopoint counts as close to the optimum mid-October period identified by Moore (2004).

5 Acknowledgements

Thanks to Catie Kroeger, Rachel Obern, Kyle Morrison and Ray Buchheit for taking some of the photographs in 2011, and all of them in 2012. Many thanks to Barry Baker for his advice on the use of TRIM and for his comments on an earlier draft of the report. This project was funded in part by the Department of Conservation's Conservation Services Programme partially through a levy on the quota holders of relevant commercial fisheries, and by the Ministry of Business, Innovation and Employment-funded Threatened Marine Megafauna project.

6 References

Baker, G.B., Jensz, K., Cunningham, R. (2011) Data collection of demographic, distributional and trophic information on the white-capped albatross to allow estimation of effects of fishing on population viability – 2010 Field Season. Report prepared for the Ministry of Fisheries, PRO2006-01J, August 2011. Latitude 42 Environmental Consultants, Kettering, Australia.

Caughley, G. (1980) *Analysis of vertebrate populations*. Wiley, New York.

DeLord, K., Barbraud, C., Weimerskirch, H. (2004) Long-term trends in population size of King penguins at Crozet archipelago: environmental variability and density dependence? *Polar Biology,* 27: 793-800.

Gill, B.J., Bell, B.D., Chambers, G.K., Medway, D.G., Palma, R.L., Scofield, R.P., Tennyson, A.J.D., Worthy, T.H. (2010) *Checklist of the birds of New Zealand, Norfolk and Macquarie Islands, and the Ross Dependency, Antarctica.* Ornithological Society of New Zealand & Te Papa Press, Wellington.

McCullagh, P., Nelder, J.A. (1989) *Generalised Linear Models*. 2nd ed. Chapman & Hall, London.

Moore, P.J. (1999) Counting mollymawks on Campbell Island: a guide to techniques and field procedures. *Department of Conservation Technical Series,* 16. Department of Conservation, Wellington.

Moore, P.J. (2002) Counting mollymawks on Campbell Island – data supplements. *Science & Research Internal Report,* 192. Department of Conservation, Wellington.

Moore, P. (2004) Abundance and population trends of mollymawks on Campbell Island. *Science for Conservation,* 242. Department of Conservation, Wellington.

Moore, P.J., Blezard, R. 1999 Photographs of Campbell Island mollymawk colonies. A guide to photopoints, historical comparisons, and counting mollymawks. *Department of Conservation Technical Series,* 17. Department of Conservation, Wellington.

Pannekoek, J., van Strien, A.J. (1996) TRIM – trends and indices for monitoring data. *Research Paper*, 9634, Statistics Netherlands, Voorburg.

Richard, Y., Abraham, E.R., Filippi, D. (2011) Assessment of the risk to seabird populations from New Zealand commercial fisheries. Final Research Report for projects IPA2009/19 and IPA2009/20. Unpublished report held by the Ministry of Fisheries.

Waugh, S.M., Weimerskirch, H., Moore, P.J., Sagar, P.M. (1999) Population dynamics of black-browed and grey-headed albatrosses *Diomedea melanophrys* and *D. chrysostoma* at Campbell Island, New Zealand, 1942-1996. *Ibis,* 141: 216-225.